

# Collaborative Laboratory Commissioning and Sustaining the Optimal Building

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Facility Dynamics

# Overview

- Define Commissioning (Cx)
- Put the Cx process in the Context of a State of the Art Laboratory Facility (NIH B50)
- Present a software tool (ComIT) that facilitates a collaborative, paperless Cx process and provides an operator interface to building information
- Review laboratory functional performance testing
- Discuss Getting the Most From Cx and how to Sustain it
- Present a tool for continuous commissioning (PACRAT)

# Commissioning

- The systematic process of ensuring that all building systems perform interactively according to the design intent and the Owner's operational needs.
  - All design/construct parties collaborate
  - Begins in planning stages and proceeds into occupancy

# Commissioning Goals

- Ensure facilities are **designed** to meet Owner's needs
- Ensure facilities are **installed** properly
- Ensure intent and installation are fully **documented**
- Ensure Operators are fully **trained**
- Facilities are **optimized** for the actual occupancy

# Lab Commissioning

- Focus on
  - Safety
  - Reliability
  - Energy Efficiency
  - Persistence
- Essential for today's complex Laboratories

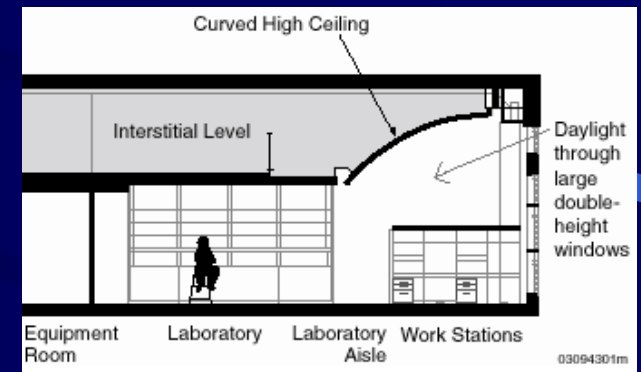
# NIH Building 50

- 300,000 sf
  - 190,000 sf of Research Space
- Seven Occupied Levels (each w/an Interstitial)
- Structural and Cell Biology Research
- Specialty Spaces
  - Vivarium w/BL 3
  - BL 3 Labs
  - NMR
  - EM Suite



# NIH Building 50

- Energy Features
  - Full VAV Fume Hoods & Tracking Zones
  - Desiccant Heat Wheel
  - Day Lighting
  - Variable Speed Drives
  - Commissioning
  - M&V



# B50 Systems Overview

- Once Through Air Systems (450,000 cfm)
  - Headered Systems
  - VAV Flow Tracking Lab Zones/Fume Hoods
  - Desiccant Heat Wheel (General Exhaust)
- Electrical Network Feed with Generator Backup
- Campus Loop Connections for
  - Steam/Condensate
  - Chilled Water
  - Compressed Air
  - Domestic Water
- Lab Air, Vacuum, and Gasses
- Pure Water
- Clean Steam



# B50 Process Overview

- Design Phase
  - Peer Review
  - Integrate and Coordinate Cx Requirements
- Construction Phase
  - Review Submittals
  - Collaboratively develop start up procedures
  - Fume Hood Mock Up
  - Contractor start up and documentation
  - Training
- Acceptance Phase
  - Functional Performance Testing
    - Start up checks with Sampling with maximum failure limit
    - Intra and Inter-system functional and performance tests
    - Crash Testing
  - Safety Certifications
  - Design Intent Training
- Occupancy Phase
  - Opposite Season Testing
  - Optimization
  - Capacity Assessment

# B50 Cx Challenges

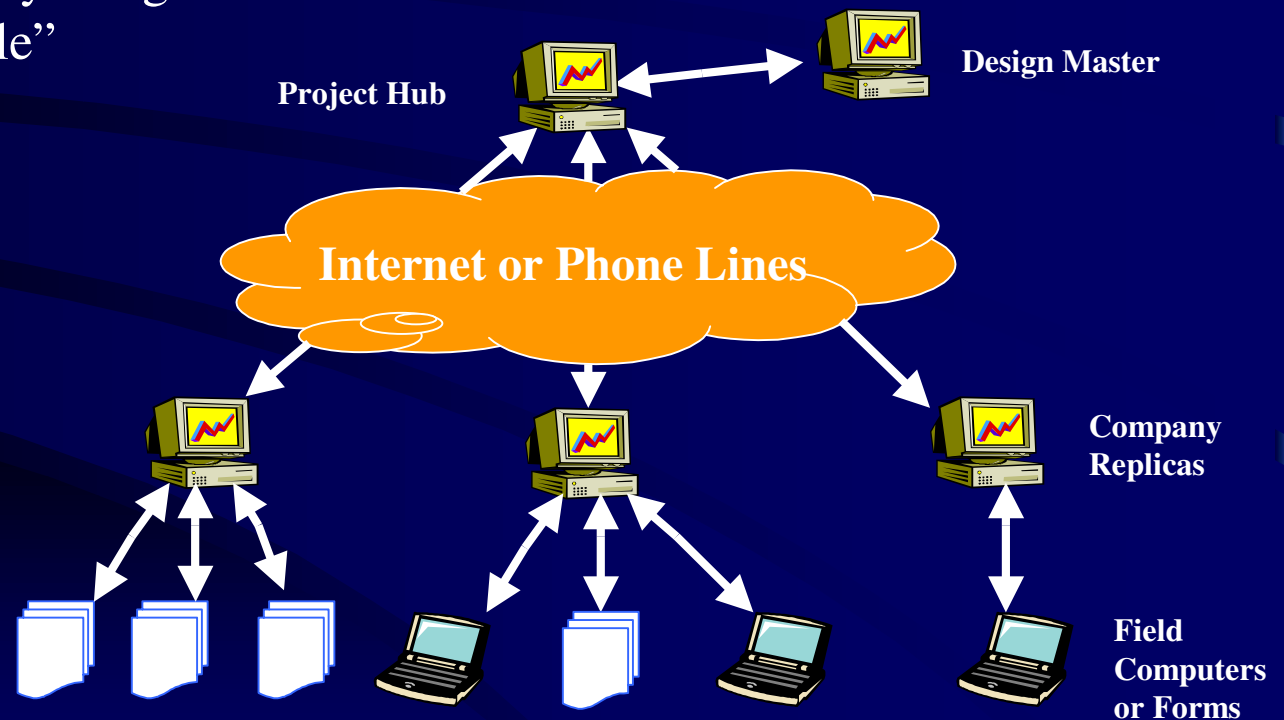
- Phased Occupancy and Tight Scheduling
- “Failure Matrix”
- Enhanced Fume Hood Testing Requirements
- Fluid Environment
- Special/Critical Occupancies

# ComIT

- Commissioning Information Tool
- Collaborative software tool that applies Information Technology to enhance the Cx process and provide O&M information to the operators electronically
- Provides a collaborative environment via the internet for all parties involved to generate and record commissioning procedures
- Provides an “Issue Management” or “Action List” tracking system that maintains threaded discussions, status of the issue, direct links to related documents, and associates the issue with building elements
- Provides near real time status of commissioning and “Action Items”
- Provides electronic equipment data that can be imported to the Maintenance/Asset Management Software
- Integrating all the diverse data through a common user friendly interface that can provide an effective tool for the facilities personnel

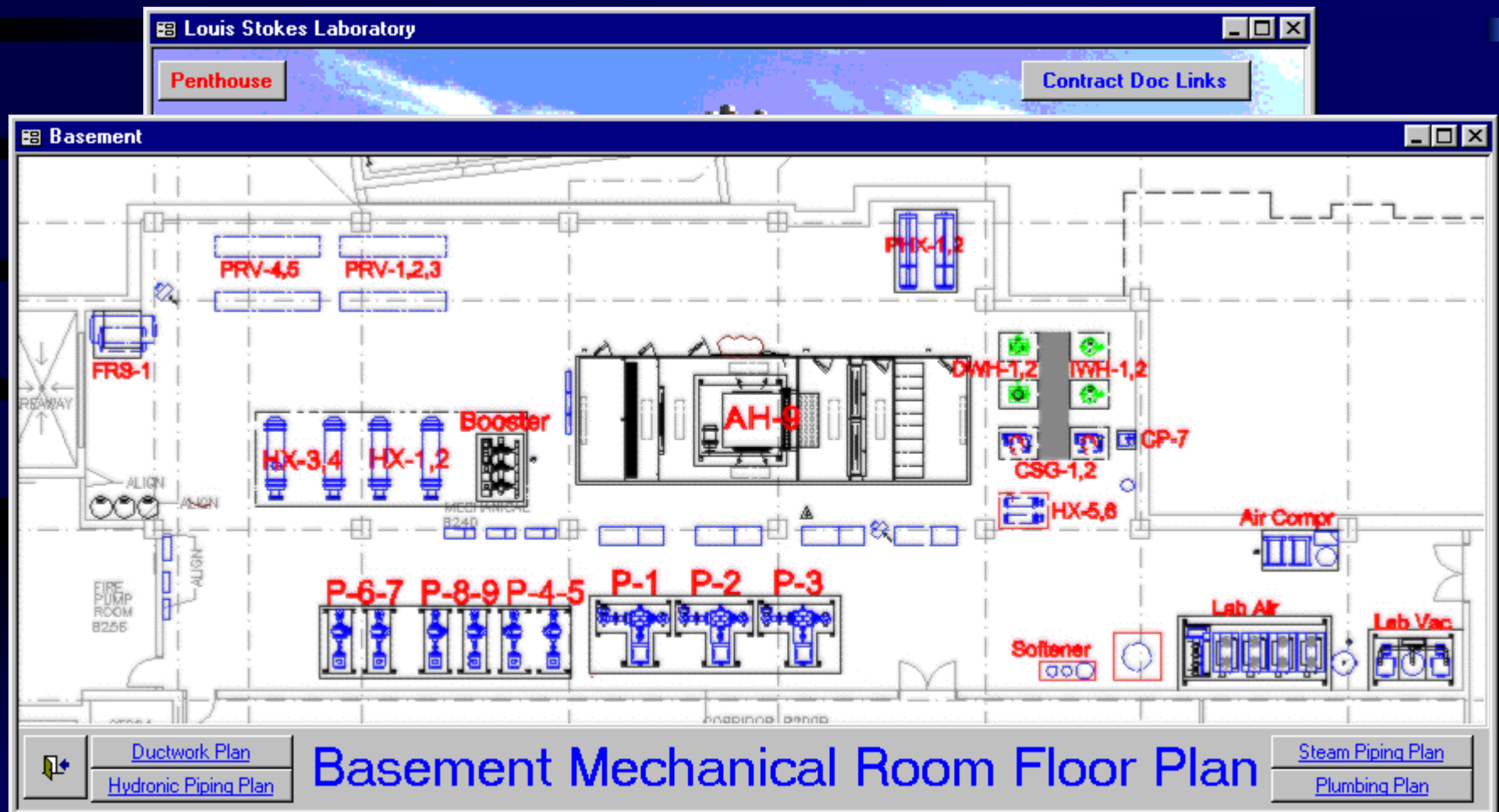
# ComIT

- Collaboration Via the Internet
  - Thick or Thin Client
  - Local Project Files with Synchronization
  - More Efficient
  - More Current
  - More Tightly Integrated
  - More “Agile”



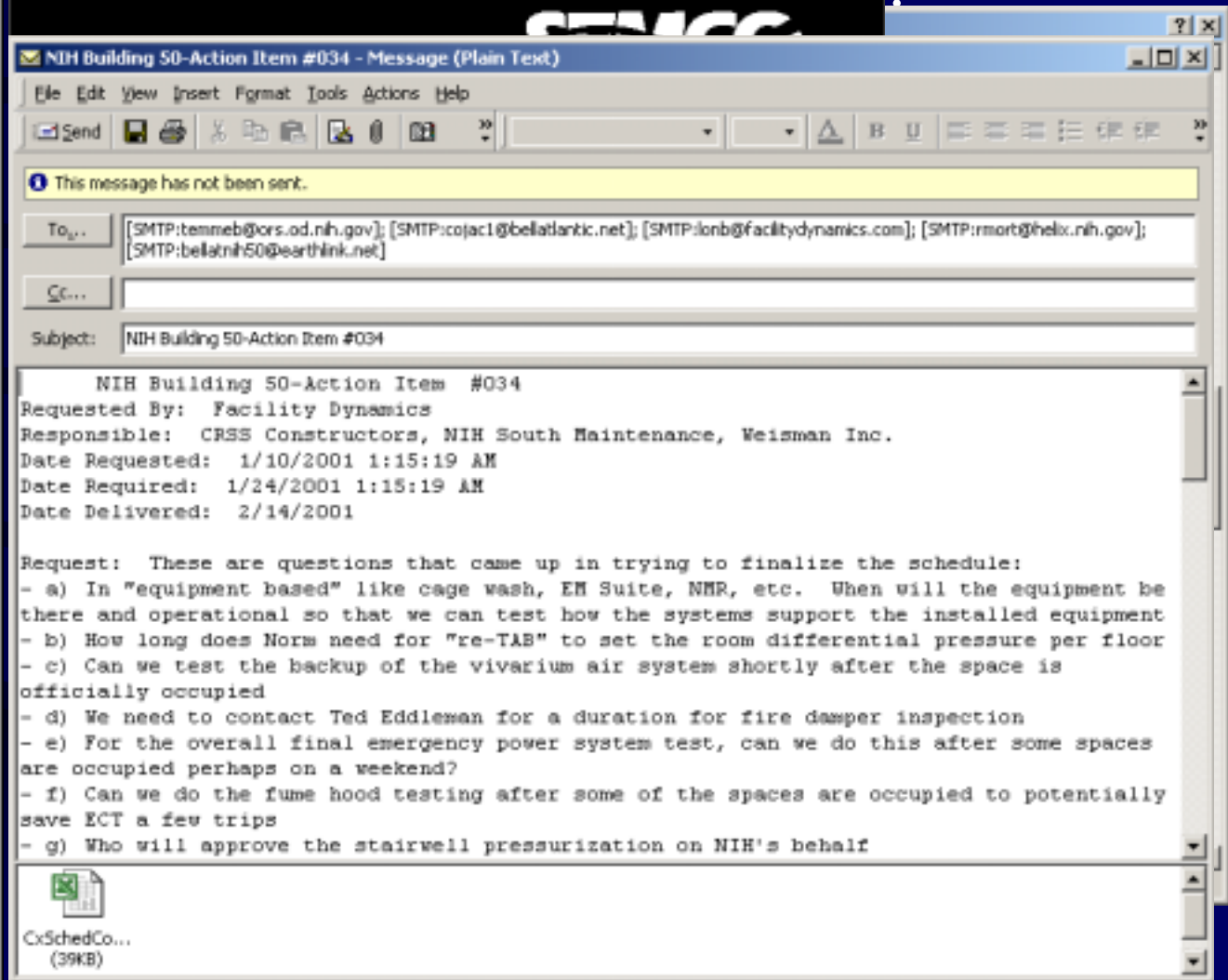
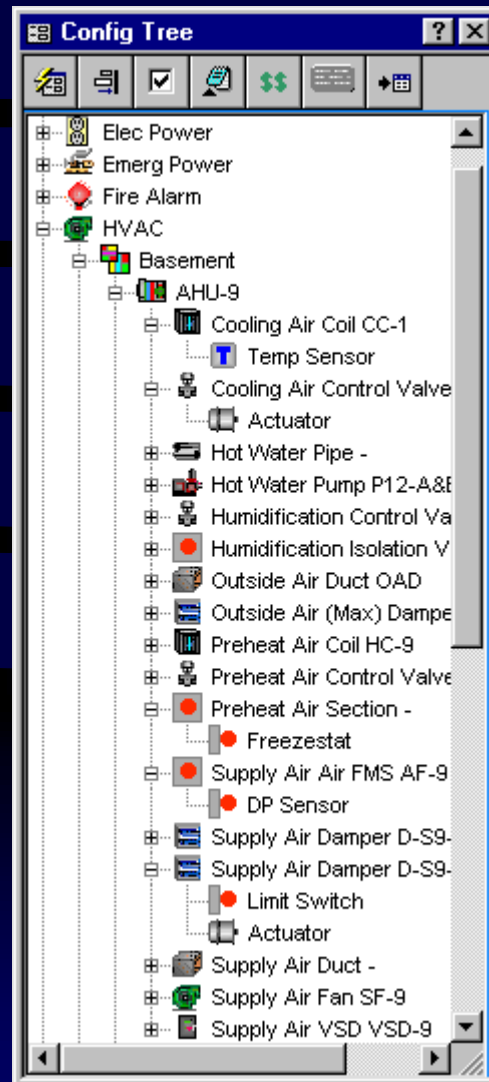
# ComIT

- Graphical Interface to Information



# ComIT

- Building Element Tree for Accessing



# Lab Testing

- Intersystem Crash Testing
  - Standard Component Failures
  - Dropped single Network Feeders and All simultaneously
    - Tuned Failure Matrix
- Progressive Pressure Zone Testing and Set Up
- Rigorous Control System Shakeout
- Fume Hood Testing
  - Mock Up to Pre-qualify
  - Dynamic Response and Turbulence Intensity Assessment
- Heat Wheel Testing
  - Efficiency and Cross Contamination
- Capacity Assessment

# Getting the Most From Lab Cx

- Budget Allocation
- Tight Coordinated Documents with Consequences
- Maintain Collaborative Environment
  - Information Management
  - Cooperative Spirit
- Involve Operators/Occupants early and extensively throughout
- Include extensive Cx scope
- “Hands on” senior experienced people directly involved
- Staying Current in a fluid environment
- Involve Safety Personnel
- Extensive integrated intersystem testing and optimization



# Sustaining Cx

- Involving **Operators** throughout the Cx process
- Effective, thorough **training** with documentation that persists
- Effective Facility **Documentation**
  - Including Design Intent and Goals/Baselines
- **Warranty** Phase Cx
- Automated **Continuous Cx**
  - Control Systems
  - **PACRAT**

# PACRAT

- Performance And Continuous Re-commissioning Analysis Tool
- Modules
  - Automated Diagnostics
  - Monitoring and Verification
  - Performance (reality) Characterization
  - Data Visualization
- Comprehensive Tool for Using Building Operational Data to Improve Facility Operation and Planning

# PACRAT Automated Diagnostics

- AH Modules



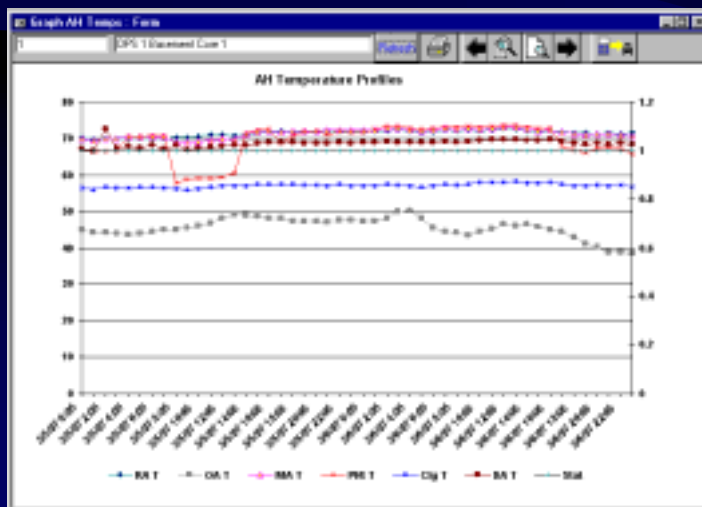
- Failed or suspect sensors
- Mis-calibrated/coordinated sensors
- Out of sequence coils and associated wasted cost and false load
- Missed free cooling opportunities (lack of economizer) and associated wasted cost
- Fighting Coils and associated wasted cost and false load
- Leaking Valves and associated wasted cost and false load
- Struggling system capacities
- Unoccupied period operation (fan and ventilation) and associated wasted cost
- Unstable and Oscillating Control
- Deviation from setpoint
- Inadequate ventilation rates along with the associated parameter statistics
- Failed outputs or those with a poor performance characteristic
- OA sensor coordination with National Weather Stations

# PACRAT Automated Diagnostics

- Hydronic System Module
  - Poor Temperature Difference
  - Reverse Bridge Flow
  - Unstable Control
  - Sensor Mis-calibration
  - Failed Output
  - Loop Overpressure
  - Struggling Valve or Pump control
  - Primary-Secondary Meter Coordination
- Chiller System Module
  - Poor Chiller Load Factor
  - Poor/Degrading Heat Exchange surfaces
  - Lack of Chiller Output/Degrading Efficiency
  - Struggling Capacity/Deviation from Setpoint
  - Excessive Cycling
- Generic/Custom
  - Excess Consumption
    - “Fume Hood Police”
  - Deviation from setpoint or range
  - Unstable Control
  - Struggling Output

# Automated Diagnostics

- **Anomaly** Information Reporting
  - Energy **Cost** **Waste**
  - Consequences
  - Applicable Details
  - **Expert** Help
  - Link to data graph



**Identified Anomalies**

Include Dates From 8/23/2000 To 9/8/2000

Air Handler Hart\_AH1 OA D Fan

Anomaly Date Range	Entry Date	Analysis Date Range	Rpt
8/23/2000 2:00:00 F - 8/28/2000 5:55:00 PM	9/18/2000	8/23/2000 - 9/8/2000	<input checked="" type="checkbox"/>

\$ Waste \$0.00 Consequence IAQ Tons Waste 0

Inadequate Ventilation through AH

Inadequate ventilation was introduced during multiple hours of an occupied period. 4 periods were found low. The lowest average ventilation airflow sensed for an occupied day group was 0. This typically means that either the MA plenum is pressurized or the sensors are out of calibration. The prescribed ventilation air flow was 1000.

Causes/Resolutions Aggregate Values Notes

Possible Cause:  
Balancing is not adequate

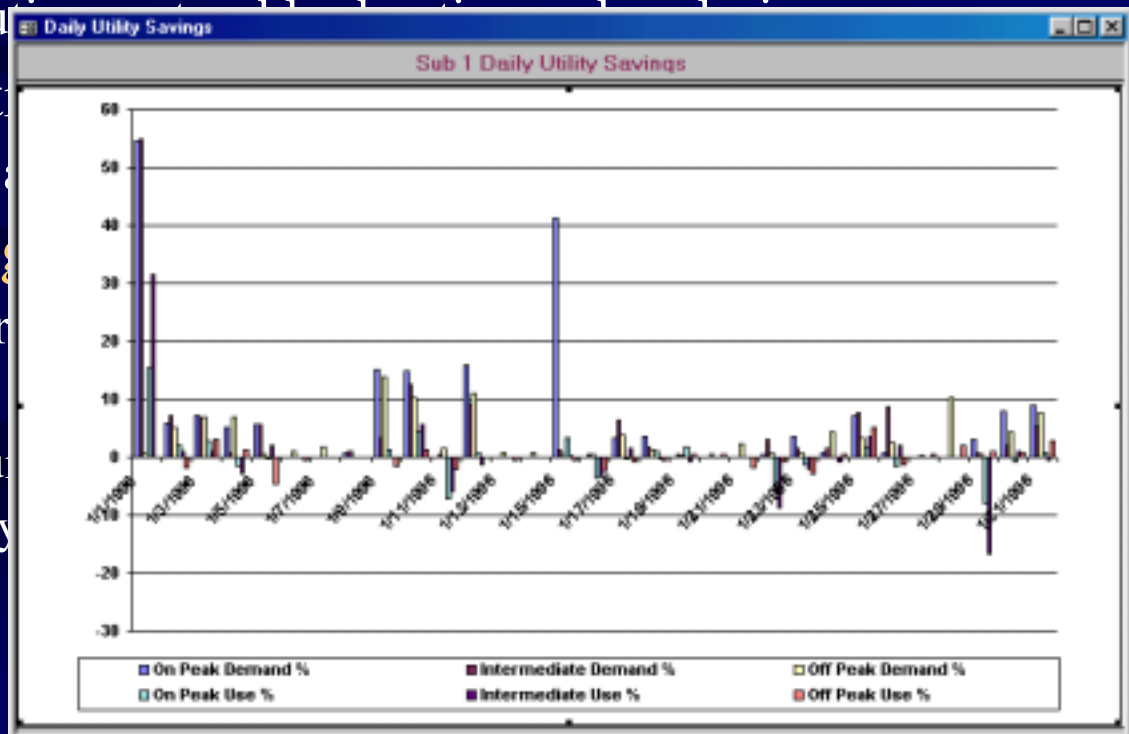
Associated Resolution:  
Balance the unit for proper minimum ventilation air flow

Record: 1 of 5

Record: 1 of 1

# PACRAT M & V

- Establish “Commissioned” Baseline
  - Multi-dimensional (neural-like)
  - Use Day Types, Hour of Day, and other parameters such as OA Temp to index base patterns
- Micro vs Macro approach
  - Uses Detailed Data in addition to Monthly Totals
  - Allows High resolution
- Establish “Conventional” Baseline
  - Directly document
- Extensive Reporting
  - Automatically Recr
  - Calculate savings
    - Print Periodic Sum
    - Graph Savings by



# Summary

- Cx is **Essential** for Complex Laboratories
- To Get the **Most** from Cx Requires
  - Adequate **Budget**
  - Effective **Collaboration** integrating the efforts of many parties
  - Aggressive, Extensive testing by **senior** personnel actively participating
  - Extensive **Operator/Occupant** involvement
- Sustaining Cx
  - Effective **Training** with Persistent Documentation
  - Effective Facility **Documentation**
  - **Warranty** Phase Cx
  - Apply State of the Art **Continuous Cx** Tools